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# The Risks of Financial Modeling: VaR and the Economic Meltdown

*Introduction*

Mr. Chairman, Mr. Ranking Member and members of this Subcommittee, my name is James Rickards, and I want to extend my deep appreciation for the opportunity and the high honor to speak to you today on a subject of the utmost importance in the management of global capital markets and the global banking system. The Subcommittee on Investigations and Oversight has a long and distinguished history of examining technology and environmental matters which affect the health and well-being of Americans. Today our financial health is in jeopardy and I sincerely applaud your efforts to examine the flaws and misuse in financial modeling which have contributed to the impairment of the financial health of our citizens and the country as a whole.

As a brief biographical note, I am an economist, lawyer and author and currently work at Omnis, Inc. in McLean, VA where I specialize in the field of threat finance and market intelligence. My colleagues and I provide expert analysis of global capital markets to members of the national security community including military, intelligence and diplomatic directorates. My writings and research have appeared in numerous journals and I am an Op-Ed contributor to the Washington Post and New York Times and a frequent commentator on CNBC, CNN, Fox and Bloomberg. I was formerly General Counsel of Long-Term Capital Management, the hedge fund at the center of the 1998 financial crisis, where I was principal negotiator of the Wall Street rescue plan sponsored by the Federal Reserve Bank of New York.

*Summary: The Problem with VaR*

The world is now two years into the worst financial crisis since the Great Depression. The IMF has estimated that the total lost wealth in this crisis so far exceeds $60 Trillion dollars, more than the cost of all of the wars of the 20th century combined. The list of causes and culprits is long including mortgage brokers making loans borrowers could not afford, investment bankers selling securities while anticipating their default, rating agencies granting triple-A ratings to bonds which soon suffered catastrophic losses, managers and traders focused on short-term profits and bonuses at the expense of their institutions, regulators acting complacently in the face of growing leverage and imprudence and consumers spending and borrowing at non-sustainable rates based on a housing bubble which was certain to burst at some point. This story, sadly, is by now well known.

What is less well-known is that behind all of these phenomena were quantitative risk management models which told interested parties that all was well even as the bus was driving over a cliff. Mortgage brokers could not have made unscrupulous loans unless Wall Street was willing to buy them. Wall Street would not have bought the loans unless they could package them into securities which their risk models told them had a low risk of loss. Investors would not have bought the securities unless they had triple-A ratings. The rating agencies would not have given those ratings unless their models told them the securities were almost certain to perform as expected. Transaction volumes would not have reached the levels they did without leverage in financial institutions. Regulators would not have approved that leverage unless they had confidence in the risk models being used by the regulated entities. In short, the entire financial edifice, from borrower to broker to banker to investor to rating agency to regulator, was supported by a belief in the power and accuracy of quantitative financial risk models. Therefore an investigation into the origins, accuracy and performance of those models is not ancillary to the financial crisis; it is not a footnote; it is the heart of the matter. Nothing is more important to our understanding of this crisis and nothing is more important to the task of avoiding a recurrence of the crisis we are still living through.

Unfortunately, we have been here before. In 1998, western capital markets came to the brink of collapse, owing to the failure of a hedge fund, Long-Term Capital Management, and a trillion dollar web of counterparty risk with all of the major banks and brokers at that time. Then Fed Chairman Alan Greenspan and Treasury Secretary Robert Rubin called it the worst financial crisis in over 50 years. The amounts involved and the duration of the crisis both seem small compared to today's catastrophe, however, it did not seem that way at the time. Capital markets really did teeter on the brink of collapse; I know, I was there. As General Counsel of Long-Term Capital Management, I negotiated the bail out which averted an even greater disaster at that time. What is most striking to me now as I look back is how nothing changed and how no lessons were applied.

The lessons were obvious at the time. LTCM had used fatally flawed VaR risk models. LTCM had used too much leverage. LTCM had transacted in unregulated over-the-counter derivatives instead of exchange traded derivatives. The solutions were obvious. Risk models needed to be changed or abandoned. Leverage needed to be reduced. Derivatives needed to be moved to exchanges and clearinghouses. Regulatory oversight needed to be increased.

Amazingly the United States Government did the opposite. The repeal of Glass-Steagall in 1999 allowed banks to act like hedge funds. The Commodities Futures Modernization Act of 2000 allowed more unregulated derivatives. The

Basle II accords and SEC regulations in 2004 allowed increased leverage. It was as if the United States had looked at the near catastrophe of LTCM and decided to double-down.

What reason can we offer to explain this all-in approach to financial risk? Certainly the power of Wall Street lobbyists and special interests cannot be discounted. Alan Greenspan played a large role through his belief that markets could self-regulate through the intermediation of bank credit. In fairness, he was not alone in this belief. But none of this could have prevailed in the aftermath of the 1998 collapse without the assurance and comfort provided by quantitative risk models. These models, especially Value at Risk, cast a hypnotic spell, as science often does, and assured bankers, investors and regulators that all was well even as the ashes of LTCM were still burning.

What are these models? What is the attraction that allows so much faith to be placed in them? And what are the flaws which lead to financial collapse time and time again?

The term "Value at Risk" or VaR is used in two senses. One meaning refers to the assumptions, models and equations which constitute the risk management systems most widely used in large financial institutions today. The other meaning refers to the output of those systems, as in, "our VaR today is $200 million" which refers to the maximum amount the institution is expected to lose in a single day within some range of probability or certainty usually expressed at the 99% level. For purposes of this testimony, we will focus on VaR in the first sense. If the models are well founded then the output should be of some value. If not, then the output will be unreliable. Therefore the proper focus of our inquiry should be on the soundness of the models themselves.

Furthermore, any risk management system is only as good as the assumptions behind it. It seems fair to conclude that based on a certain set of assumptions, the quantitative analysts and computer developers are able within reason to express those assumptions in equations and to program the equations as computer code. In other words, if the assumptions are correct then it follows that the model development and the output should be reasonably correct and useful as well. Conversely, if the assumptions are flawed then no amount of mathematical equation writing and computer development will compensate for this deficiency and the output will always be misleading or worse. Therefore, the root of our inquiry into models should be an examination of the assumptions behind the models.

In broad terms, the key assumptions are the following:

<u>The Efficient Market Hypothesis (EMH)</u>: This assumes that investors and market participants behave rationally from the perspective of wealth maximization and will respond in a rational manner to a variety of inputs including price signals and

news. It also assumes that markets efficiently price in all inputs in real time and that prices move continuously and smoothly from one level to another based on these new inputs.

The Random Walk: This is a corollary to EMH and assumes that since markets efficiently price in all information, no investor can beat the market consistently because any information which an investor might rely on to make an investment decision is already reflected in the current market price. This means than future market prices are independent of past market prices and will be based solely on future events that are essentially unknowable and therefore random.

Normally Distributed Risk: This is also a corollary to EMH and says that since future price movements are random, their degree distribution (i.e. relationship of frequency to severity of events) will also be random like a coin toss or roll of the dice. This random or normal degree distribution is also referred to as Gaussian and is most frequently represented as a bell curve in which the large majority of outcomes are bunched in a region of low severity with progressively fewer outcomes shown in the high severity region. Because the curve tails off steeply, highly extreme events are so rare as to be almost impossible.

Value at Risk would be a fine methodology but for the fact that all three of these assumptions are wrong. Markets are *not* efficient. Future prices are *not* independent of the past. Risk is *not* normally distributed. As the saying goes, "Besides that, Mrs. Lincoln, how was the play?" Let's take these points separately.

Behavioral economics has done a masterful job of showing experimentally and empirically that investors do not behave rationally and that markets are not rational but are prone to severe shocks or mood swings. Examples are numerous but some of the best known are risk aversion (i.e. investors put more weight on avoiding risk than seeking gains), herd mentality (i.e. investors buy stocks when others are buying and sell when others are selling leading to persistent losses) and various seasonal effects. Prices do not smoothly and continuously move from one price level to the next but have a tendency to gap up or down in violent thrusts depriving investors of the chance to get out before large losses are incurred.

Similarly, prices to not move randomly but are highly dependent on past price movements. In effect, relevant news will be discounted or ignored for sustained periods of time until a kind of tipping point is achieved at which point investors will react *en masse* to what is mostly old news mainly because other investors are doing likewise. This is why markets exhibit periods of low and high volatility in succession, why markets tend to overshoot in response to fundamental news and why investors can profit consistently by momentum trading which exploits an understanding of these dynamics.

Finally, the normal distribution of risk has been known to be false at least since the early 1960's when published studies of time series of prices showed price distributions to be shaped in what is known as a power curve rather than a bell curve. This has been borne out by many studies since. A power curve has fewer low impact events than the bell curve but has far more high impact events. This corresponds exactly to the actual market behavior we have seen including frequent extreme events such as the stock market crash of 1987, the Russian-LTCM collapse of 1998, the dot com bubble collapse of 2000 and the housing collapse of 2007. Statistically these events should happen once every 1,000 years or so in a bell curve distribution but are expected with much greater frequency in a power curve distribution. In short, a power curve corresponds to market reality while a bell curve does not.

How is it possible that our entire financial system has come to the point that it is risk managed by a completely incorrect system?

The Nobelist, Daniel Kahneman, tells the story of a Swiss Army patrol lost in the Alps in a blizzard for days. Finally the patrol stumbles into camp, frostbitten but still alive. The Commander asks how they survived and the patrol leader replies, "We had a map." The Commander looks at the map and says, "This is a map of the Pyrenees; you were in the Alps." "Yes," comes the reply; "but we had a map." The point is that sometimes bad guidance is better than no guidance; it gives you confidence and an ability to function even though your system is flawed.

So it is with risk management on Wall Street. The current system, based on the idea that risk is distributed in the shape of a bell curve, is flawed and practitioners know it. Practitioners treat extreme events as outliers and develop mathematical fixes. They call extreme events fat tails and model them separately from the rest of the bell curve. They use stress tests to gauge the impact of extreme events. The problem is they never abandon the bell curve. They are like medieval astronomers who believe the sun revolves around the earth and are furiously tweaking their geocentric math in the face of contrary evidence. They will never get this right; they need their Copernicus.

But the right map exists. It's called a power curve. It says that events of any size can happen and extreme events happen more frequently than the bell curve predicts. There is no need to treat fat tails as a special case; they occur naturally on power curves. And power curves are well understood by scientists because they apply to extreme events in many natural and man-made systems from power outages to earthquakes.

Power curve analysis is not new. The economist, Vilfredo Pareto, observed in 1906 that wealth distributions in every society conform to a power curve; in effect, there is one Bill Gates for every 100 million average Americans. Benoit

Mandelbrot pioneered empirical analysis in the 1960's that showed market prices move in power curve patterns.

So why have we gone down the wrong path of random walks and normal distributions for the past 50 years? The history of science is filled with false paradigms that gained followers to the detriment of better science. People really did believe the sun revolved around the earth for 2,000 years and mathematicians had the equations to prove it. The sociologist, Robert K. Merton, called this the Matthew Effect from a New Testament verse that says, "For to those who have, more will be given..." The idea is that once an intellectual concept attracts a critical mass of supporters it becomes entrenched while other concepts are crowded out of the marketplace of ideas.

Another reason is that practitioners of bell curve science became infatuated with the elegance of their mathematical solutions. The Black-Scholes options formula is based on bell curve type price movements. The derivatives market is based on variations of Black-Scholes. Wall Street has decided that the wrong map is better than no map at all - as long as the math is neat.

Why haven't scientists done more work in applying power curves to capital markets? Some excellent research has been done. But one answer is that power curves have low predictive value. Researchers approach this field to gain an edge in trading and once the edge fails to materialize they move on. But the Richter Scale, a classic power curve, also has low predictive value. That does not make earthquake science worthless. We know that 8.0 earthquakes are *possible* and we build cities accordingly even if we cannot know *when* the big one will strike.

We can use power curve analysis to make our financial system more robust even if we cannot predict financial earthquakes. One lesson of power curves is that as you increase the scale of the system, the risk of a mega-earthquake goes up exponentially. If you increase the value of derivatives by a factor of 10, you may be increasing risk by a factor of 10,000 without even knowing it. This is not something that Wall Street or Washington currently comprehend.

Let's abandon the bell curve once and for all and accelerate empirical research into the proper risk metrics of event distributions. Even if predictive value is low, there is value in knowing the limits of our knowledge. Understanding the way risk metastasizes with scale might be lesson enough. It would offer a proper dose of humility to those trying to supersize banks and regulators.

*Detailed Analysis - History of VaR Failures*

The empirical failures of the Efficient Market Hypothesis and VaR are well known. Consider the October 19, 1987 stock market crash in which the market fell 22.6% in one day; the December 1994 Tequila Crisis in which the Mexican

Peso fell 85% in one week; the September 1998 Russian-LTCM crisis in which capital markets almost ceased to function; the March 2000 dot com collapse during which the NASDAQ fell 80% over 30 months, and the 9-11 attacks in which the NYSE first closed and then fell 14.3% in the week following its reopening. Of course, to this list of extreme events must now be added the financial crisis that began in July 2007. Events of this extreme magnitude should, according to VaR, either not happen at all because diversification will cause certain risks to cancel out and because rational buyers will seek bargains once valuations deviate beyond a certain magnitude, or happen perhaps once every 1,000 years (because standard deviations of this degree lie extremely close to the *x*-axis on the bell curve which corresponds to a value close to zero on the *y*-axis, i.e., an extremely low frequency event). The fact that *all* of these extreme events took place in just over 20 years is completely at odds with the predictions of VaR in a normally distributed paradigm.

Practitioners treated these observations not as fatal flaws in VaR but rather as anomalies to be explained away within the framework of the paradigm. Thus was born the "fat tail" which is applied as an embellishment on the bell curve such that after approaching the *x*-axis (i.e., the extreme low frequency region), the curve flattens to intersect data points representing a cluster of highly extreme but not so highly rare events. No explanation is given for what causes such events; it is simply a matter of fitting the curve to the data (or ignoring the data) and moving on without disturbing the paradigm. This process of pinning a fat tail on the bell curve reached its apotheosis in the invention of generalized autoregressive conditional heteroskedasicity or GARCH and its ilk, which are analytical techniques for modeling the section of the degree distribution curve containing the extreme events as a separate case and feeding the results of this modeling into a modified version of the curve. A better approach would have been to ask the question: if a normal distribution has a fat tail, is it really a normal distribution?

A Gaussian distribution is not the only possible degree distribution. One of the most common distributions in nature, which accurately describes many phenomena, is the power curve which shows that the severity of an event is inversely proportional to its frequency with the proportionality expressed as an exponent. When graphed on a double logarithmic scale, the power law describing financial markets risk is a straight line sloping downward from left to right; the negative exponent is the slope of the line.

This difference is not merely academic. Gaussian and power curve distributions describe two *entirely different phenomena*. Power curves accurately describe a class of phenomena known as nonlinear dynamical systems which exhibit scale invariance, i.e., patterns are repeated at all scales.

The field of nonlinear dynamical systems was enriched in the 1990s by the concept of self-organized criticality. The idea is that actions propagate throughout systems in a *critical* chain reaction. In the critical state, the probability that an action will propagate is roughly balanced by the probability that the original action will dissipate. In the subcritical state, the probability of extensive effects from the initial action is low. In the supercritical state, a single minor action can lead to a catastrophic collapse. Such states have long been observed in physical systems, e.g., nuclear chain reactions in uranium piles, where a small amount of uranium is relatively harmless (*subcritical*) and larger amounts can either be carefully controlled to produce desired energy (*critical*), or can be shaped to produce atomic explosions (*supercritical)*.

The theory of financial markets existing in a critical state cannot be tested in a laboratory or particle accelerator in the same fashion as theories of atomic physics. Instead, the conclusion that financial markets are a nonlinear critical state system rests on two non-experimental bases; one deductive, one inductive. The deductive basis is the ubiquity of power curves as a description of the behavior of a wide variety of complex systems in natural and social sciences, e.g., earthquakes, forest fires, sunspots, polarity, drought, epidemiology, population dynamics, size of cities, wealth distribution, etc. This is all part of a more general movement in many natural and social sciences from 19th and early 20th century equilibrium models to non-equilibrium models; this trend has now caught up with financial economics.

The inductive basis is the large variety of capital markets behavior which has been empirically observed to fit well with the nonlinear paradigm. It is certainly more robust than VaR when it comes to explaining the extreme market movements described above. It is consistent with the fact that extreme events are not necessarily attributable to extreme causes but may arise spontaneously in the same initial conditions from routine causes.

While extreme events occur with much greater than normal frequency in nonlinear critical state systems, these events are nevertheless limited by the scale of the system itself. If the financial system is a self-organized critical system, as both empirical evidence and deductive logic strongly suggest, the single most important question from a risk management perspective is: *what is the scale of the system?* Simply put, the larger the scale of the system, the greater the potential collapse with correlative macroeconomic and other real world effects.

The news on this front is daunting. There is no normalized scale similar to the Richter Scale for measuring the size of markets or the size of disruptive events that occur within them, however, a few examples will make the point. According to recent estimates prepared by the McKinsey Global Institute, the ratio of world financial assets to world GDP grew from 100% in 1980 to 200% in 1993 to 316% in 2005. Over the same period, the absolute level of global financial assets increased from $12 trillion to $140 trillion. The drivers of this exponential increase in scale are globalization, derivative products, and leverage.

Globalization in this context is the integration of capital markets across national boundaries. Until recently there were specific laws and practices that had the effect of fragmenting capital markets into local or national venues with little interaction. Factors included withholding taxes, capital controls, protectionism, non-convertible currencies, licensing, regulatory and other restrictions that tilted the playing field in favor of local champions and elites. All of these impediments have been removed over the past 20 years to the point that the largest stock exchanges in the United States and Europe (NYSE and Euronext) now operate as a single entity.

Derivative products have exhibited even faster growth than the growth in underlying financial assets. This stems from improved technology in the structuring, pricing, and trading of such instruments and the fact that the size of the derivatives market is not limited by the physical supply of any stock or commodity but may theoretically achieve *any* size since the underlying instrument is notional rather than actual. The total notional value of all swaps increased from $106 trillion to $531 trillion between 2002 and 2006. The notional value of equity derivatives increased from $2.5 trillion to $11.9 trillion over the same period while the notional value of credit default swaps increased from $2.2 trillion to $54.6 trillion.

Leverage is the third element supporting the massive scaling of financial markets; margin debt of U.S. brokerage firms more than doubled from $134.58 billion to $293.2 billion from 2002 to 2007 while the amount of total assets per dollar of equity at major U.S. brokerage firms increased from approximately $20 to $26 in the same period. In addition, leveraged investors invest in other entities which use leverage to make still further investments. This type of layered leverage is impossible to unwind in a panic.

There can be no doubt that capital markets are larger and more complex than ever before. In a dynamically complex critical system, this means that the size of the maximum possible catastrophe is *exponentially* greater than ever. Recalling that systems described by a power curve allow events of all sizes and that such events can occur at any time, particularly when the system is supercritical, the conclusion is inescapable that progressively greater financial catastrophes of the type we are experiencing today should be expected frequently

The more advanced risk practitioners have long recognized the shortcomings of using VaR in a normally distributed paradigm to compute risk measured in standard deviations from the norm. This is why they have added stress testing as an alternative or blended factor in their models. Such stress testing rests on historically extreme events such as the market reaction to 9-11 or the stock market crash of 1987. However, this methodology has its own flaws since the worst outcomes in a dynamically complex critical state system are not bounded by history but are only bounded by the scale of the system itself. Since the system is larger than ever, there is nothing in historical experience that provides a guide to the size of the largest catastrophe that can arise today. The fact that the financial crisis which began in July 2007 has lasted longer, caused greater losses and been more widespread both geographically and sectorally than most analysts predicted or can explain is because of the vastly greater scale of the financial system which produces an exponentially greater catastrophe than has ever occurred before. This is why the past is not a guide and why the current crisis may be expected to produce results as severe as the Great Depression of 1929-1941.

*Policy Approaches and Recommendations*

A clear understanding of the structures and vulnerabilities of the financial markets points the way to solutions and policy recommendations. These recommendations fall into the categories of limiting scale, controlling cascades, and securing informational advantage.

To explain the concept of limiting scale, a simple example will suffice. If the U.S. power grid east of the Mississippi River were at no point connected to the power grid west of the Mississippi River, a nationwide power failure would be an extremely low probability event. Either the “east system” or the “west system” could fail catastrophically in a cascading manner but both systems could not fail simultaneously except for entirely independent reasons because there are no nodes in common to facilitate propagation across systems. In a financial context, governments should give consideration to preventing mergers that lead to globalized stock and bond exchanges and universal banks. The first order efficiencies of such mergers are outweighed by the risks of large-scale failure especially if those risks are not properly understood and taken into account.

Another example will help to illustrate the relationship between the scale of a system and extent of the greatest catastrophe possible in that system. Imagine a vessel with a large hold. The hold is divided into three equal sections separated by watertight bulkheads. If a hole is punched in one section and that section is completely filled with water, the vessel will still float. Now imagine the watertight bulkheads are removed and the same hole is punched into the vessel. In this case, the entire hold will fill with water and the vessel will sink. In this example, the area of the hold can be thought of as the relevant dynamic system. The sinking of the vessel represents the catastrophic failure of the system. When the bulkheads are in place we have three small systems. When the bulkheads are removed we have one large system. By removing the bulkheads we increased the scale of the system by a factor of three. But the likelihood of failure did not increase by a factor of three; it went from practically zero to practically 100%. The system size tripled but the risk of sinking went up exponentially. By removing the bulkheads we created what engineers call a "single point of failure", i.e. one hole is now enough to sink the entire vessel.

Something similar happened to our financial system between 1999 and 2004. This began with the repeal of Glass-Steagall in 1999 which can be thought of as removing the watertight bulkheads separating commercial banks and investment banks. This was exacerbated by the Commodities Futures Modernization Act of 2000 which removed the prohibition on many kinds of derivatives. This allowed banks to increase the scale of the system through off-balance sheet transactions. Finally, in 2004, the SEC amended the broker-dealer net capital rule in such a way that allowed brokers to go well-beyond the traditional 15:1 leverage ratio and to use leverage of 30:1 or more. All three of these events increased the scale of the system by allowing regulated financial institutions to enter new markets, trade new products and use increased leverage. Using a power curve analysis, we see that while the scale of the system was increased in a linear way (by a factor of 3, 5, 10 or 50 depending on the product) the risk was increasing in a nonlinear way (by a factor of 100, 1000, or 10,000 depending on the slope of the power curve). VaR models based on normal distributions were reporting that risk was under control and sounding the all clear signal because so much of the risk was offsetting or seen to cancel out in the models. However, a power curve model would have been flashing a red alert sign because it does not depend on correlations, instead it sees risk as an emergent property and an exponential function of scale.

The fact that government opened the door to instability does not necessarily mean that the private sector had to rush through the door to embrace the brave new world of leveraged risk. For that we needed VaR. Without VaR models to tell bankers that risk was under control, managers would not have taken so much risk even if government rules allowed them to do so. Self-interest would have constrained them somewhat as Greenspan expected. But with VaR models telling senior management that risk was contained the new government rules became an open invitation to pile on massive amounts of risk which bankers promptly did.

Our financial system was relatively stable from 1934-1999 despite occasional failures of institutions (such as Continental Illinois Bank) and entire sectors (such as the S&L industry). This 65-year period can be viewed as the golden age of compartmented banking and moderate leverage under Glass-Steagall and the SEC's original net capital rule. Derivatives themselves were highly constrained by the Commodity Exchange Act. In 1999, 2000 and 2004 respectively, all three of these watertight bulkheads were removed. By 2006 the system was poised for the most catastrophic financial collapse in history. While subprime mortgage failures provided the catalyst, it was the scale of the system itself which caused the damage. The catalyst could just as well have come from emerging markets, commercial real estate or credit default swaps. In a dynamically critical system, the catalyst is always less important than the chain reaction and the reaction in this case was a massive collapse.

The idea of controlling cascades of failure is, in part, a matter of circuit breakers and pre-rehearsed crisis management so that nascent collapses do not spin into full systemic catastrophes before regulators have the opportunity to prevent the spread. The combination of diffuse credit and layered leverage makes it infeasible to assemble all of the affected parties in a single room to discuss solutions. There simply is not enough time or condensed information to respond in real time as a crisis unfolds.

One significant circuit breaker which has been discussed for over a decade but which has still not been fully implemented is a clearinghouse for all over-the-counter derivatives. Experience with clearinghouses and netting systems such as the Government Securities Clearing Corporation shows that gross risk can be reduced 90% or more when converted to net risk through the intermediation of a clearinghouse. Bearing in mind that a parametric decrease in scale produces an exponential decrease in risk in a nonlinear system, the kind of risk reduction that arises in a clearinghouse can be the single most important step in the direction of stabilizing the financial system today; much more powerful than bail outs which do not reduce risk but merely bury it temporarily.

A clearinghouse will also provide informational transparency that will allow regulators to facilitate the failure of financial institutions without producing contagion and systemic risk. Such failure (what Joseph Schumpeter called "creative destruction") is another necessary step on the road to financial recovery. Technical objections to clearinghouse implementation based on the non-uniformity of contracts can be overcome easily through consensual contractual modification with price adjustments upon joining the clearinghouse enforced by the understanding that those who refuse to join will be outside the safety net. Only by eliminating zombie institutions and creating breathing room for healthy institutions with sound balance sheets can the financial sector hope to attract sufficient private capital to replace government capital and thus re-start the credit creation process needed to produce sound economic growth.

Recently a number of alternative paradigms have appeared which not only do not rely on VaR but rather assume its opposite and build models that are more robust to empirical evidence and market price patterns. Several of these approaches are:

**Behavioral Economics** - This field relies on insights into human behavior derived from social science and psychology, in particular, the "irrational" nature of human decision making when faced with economic choices. Insights include risk aversion, herding, the presence or absence of cognitive diversity and network effects among others. While not summarized in a general theory and while not always amendable to quantitative modeling, the insights of behavioral economics are powerful and should be considered in weighing reliance on VaR-style models which do not make allowance for subjective influences captured in this approach.

**Imperfect Knowledge Economics** - This discipline (under the abbreviation IKE) attempts to deal with uncertainty inherent in capital markets by using a combination of Bayesian networks, link analysis, causal inference and probabilistic hypotheses to fill in unknowns using the known. This method is heavily dependent on the proper construction of paths and the proper weighing of probabilities in each hypothesis cell or evidence cell, however, used properly it can guide decision making without applying the straightjacket of VaR.

**Econophysics** - This is a branch of financial economics which uses insights gained from physics to model capital markets behavior. These insights include nonlinearity in dynamic critical state systems the concept of phase transitions. Such systems exhibit an unpredictably deterministic nonlinear relationship between inputs and outputs (the so-called "Butterfly Effect") and scale invariance which accords well with actual time series of capital markets prices. Importantly, this field leads to a degree distribution characterized by the power curve rather than the bell curve with implications for scaling metrics in the management of systemic risk.

It may be the case that these risk management tools work best at distinct scales. For example, behavioral economics seems to work well at the level of individual decision making but has less to offer at the level of the system as a whole where complex feedback loops cloud its efficacy. IKE may work best at the level of a single institution where the hypothesis and evidence cells can be reasonably well defined and populated. Econophysics may work best at the systemic level because it goes the furthest in its ability to model highly complex dynamics. This division of labor suggests that rather than replacing VaR with a one-size-fits-all approach, it may be best to adopt a nested hierarchy of risk management approaches resembling the following:

Econophysics
Normalized metrics for understanding *systemic* risk

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Imperfect Knowledge Economics
Processes to aid risk and resource allocation at the *enterprise* level

|

Behavioral Economics
Experimentally derived tools to aid *individual* decision making

While all of these approaches and others not mentioned here require more research to normalize metrics and build general theories, they are efficacious and robust alternatives to EMH and VaR and their development and use can serve a stabilizing function since they have a strong empirical basis unlike EMH and VaR.

In summary, Wall Street's reigning risk management paradigm consisting of VaR using a normally distributed model combined with GARCH techniques applied to the non-normal region and stress testing to account for outliers is a manifest failure. It should be replaced at the systemic level with the empirically robust model based on nonlinear complexity and critical state dynamics as described by the power curve. This method also points the way to certain solutions, most importantly the creation of an over-the-counter derivatives clearinghouse which will de-scale the system and lead to an exponential decrease in actual risk. Such a clearinghouse can also be used to improve transparency and manage failure in ways that can leave the system far healthier while avoiding systemic collapse.

Importantly, if scale is the primary determinant of risk, as appears to be the case in complex systems such as the financial markets, then it follows that de-scaling the system is the simplest and most effective way to manage risk. This does not mean that the totality of the system needs to shrink, merely that it be divided into sub-components with limited interaction. This has the same effect as installing the watertight bulkheads referred to in the example above. In this manner, severe financial distress in one sector does not automatically result in contagion among all sectors.

This effective de-scaling can be accomplished with three reforms:

1. The enactment of a modernized version of Glass-Steagall with a strict separation between commercial banking and deposit taking on the one hand and principal risk taking in capital markets on the other.

2. Strict requirements for all derivative products to be traded on exchanges subject to credit tests for firm memberships, initial margin, variation margin, position limits, price transparency and netting.

3. Higher regulatory capital requirements and reduced leverage for banks and broker-dealers. Traditional ratios of 8:1 for banks and 15:1 for brokers seem adequate provided off-balance sheet positions (other than exchange traded contracts for which adequate margin is posted) be included for this purpose.

These rules can be implemented directly and do not depend on the output of arcane and dangerous models such as VaR. Instead, they derive from another proven model, the power curve, which teaches that risk is an exponential function of scale. By de-scaling, we radically reduce risk and restore stability to individual institutions and to the system as a whole.

*Curriculum Vita of*
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**James G. Rickards** is Senior Managing Director for Market Intelligence at Omnis, Inc., a scientific consulting firm in McLean, VA. He is also Principal of Global-I Advisors, LLC, an investment banking firm specializing in capital markets and geopolitics. Mr. Rickards is a seasoned counselor, investment banker and risk manager with over thirty years experience in capital markets including all aspects of portfolio management, risk management, product structure, regulation and operations. Mr. Rickards's market experience is focused in alternative investing and derivatives in global markets.

Mr. Rickards was a first hand participant in the formation and growth of globalized capital markets and complex derivative trading strategies. He held senior executive positions at sell side firms (Citibank and RBS Greenwich Capital Markets) and buy side firms (Long-Term Capital Management and Caxton Associates) and technology firms (OptiMark and Omnis). Mr. Rickards has participated directly in many of the most significant financial events over the past 30 years including the release of US hostages in Iran (1981), the Stock Market crash of 1987, the collapse of Drexel (1990), the Salomon Bros. bond trading scandal (1991) and the LTCM financial crisis of 1998 (in which Mr. Rickards was the principal negotiator of the government-sponsored rescue). He has founded several hedge funds and fund-of-funds. His advisory clients include private investment funds, investment banks and government directorates. Since 2001, Mr. Rickards has applied his financial expertise to missions for the benefit of the US national security community.

Mr. Rickards is licensed to practice law in New York and New Jersey and the Federal Courts. Mr. Rickards has held all major financial industry licenses including Series 3 (National Commodities Futures), Series 7 (General Securities Representative), Series 24 (General Securities Principal), Series 30 (Futures Manager) and Series 63.

Mr. Rickards has been a frequent speaker at conferences sponsored by bar associations and industry groups in the fields of derivatives and hedge funds and is active in the International Bar Association. He has been the interviewed in The Wall Street Journal and on CNBC, Fox, CNN, NPR and C-SPAN and is an OpEd contributor to the New York Times and the Washington Post.

Mr. Rickards is a graduate school visiting lecturer in finance at the Kellogg School and the School of Advanced International Studies. He has delivered papers on econophysics at the Applied Physics Laboratory and the Los Alamos National Laboratory. Mr. Rickards has written articles published in academic and professional journals in the fields of strategic studies, cognitive diversity, network science and risk management. He is a member of the Business Advisory Board of Shariah Capital, Inc., an advisory firm specializing in Islamic finance and is a member of the International Business Practices Advisory Panel to the Committee on Foreign Investment in the United States (CFIUS) Support Group of the Director of National Intelligence.

Mr. Rickards holds the following degrees: LL.M. (Taxation) from the New York University School of Law; J.D. from the University of Pennsylvania Law School; M.A. in international economics from the School of Advanced International Studies, Washington DC; and a B.A. degree with honors from the School of Arts & Sciences of The Johns Hopkins University, Baltimore, MD.